Leafminer species causes California mum growers new problems

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A new serpentine leafminer, *Liriomyza trifolii* (Burgess), was first introduced into California in about 1975-76, probably on chrysanthemum cuttings from Florida. Before then, other *Liriomyza* species attacked chrysanthemums, but growers had little trouble controlling these flies with conventional insecticides. After 1975, as the species composition changed, most California growers were unable to achieve satisfactory control with organophosphate insecticides. A shift to permethrin, a pyrethroid, gave only temporary relief, and during the summer of 1980, entire chrysanthemum crops were rendered unsalable or their value was substantially reduced.

Taxonomic confusion

Surveys of cut chrysanthemums damaged by serpentine leafminers in California revealed one species—*L. trifolii*. Two other economically important species have been found mining other crops in California: *Liriomyza sativae* is commonly found on a wide range of vegetables including tomatoes, celery, and squash, and *L. huidobrensis* has been reared from aster, carnation, gypsophila, and several vegetable crops. All three species are widely distributed, feed on many different plants, and are similar in form. Collectively, these flies have been described 14 times with as many specific designations. Several excellent monographs on the taxonomy of leaf-mining Diptera were published during the 1970s, and many of these names were classified under *L. trifolii, sativae*, or *huidobrensis*.

Control is difficult

The problem on chrysanthemums has arisen, because insecticides available for use against leafminers are not as effective on *L. trifolii* as they are on *L. sativae* or *L. huidobrensis*. Field tests suggest that *L. trifolii* has developed resistance to many commercially available chemical materials. Although development of resistance has not been documented through laboratory studies, our field tests are consistent with those from other states experiencing problems with *L. trifolii*. As early as 1947-48, reduced control of *Liriomyza* sp. by chlorinated hydrocarbon insecticides (DDT, Toxaphane, and the like) on vegetables was documented in Florida. *Liriomyza trifolii* populations in California, having originated in Florida, may be descended from individuals previously exposed to chlorinated hydrocarbons.

Pyrethroids initially gave satisfactory, but short-lived control of *L. trifolii* in California. Virtually no control was achieved within a year of the first applications. Preliminary laboratory experiments demonstrated that three times the recommended rates of pyrethroid compounds were ineffective against field-collected *L. trifolii*. The rapid development of resistance may be related to earlier use of chlorinated hydrocarbon insecticides. The link may be the "kdr gene," which has been shown (in other insects) to reduce the effectiveness of both chemical groups. The "kdr gene" may be present in the California population of *L. trifolii* because of earlier exposure to chlorinated hydrocarbon insecticides in Florida. Applications of pyrethroids initially worked against such a population, but rapid selection probably took place within several generations, causing the material to be ineffective during the summer of 1980.

Biology and host range

Little information exists in the literature on the biology of *Liriomyza trifolii* as a chrysanthemum pest. Following are preliminary results on the biology of this pest under greenhouse conditions during February-March 1981 in southern California.

Adults become active at sunrise, and activity peaks during midmorning. Mating can occur at any time but is most common during daylight hours. Females feed on chrysanthemum leaves by repeatedly puncturing the surface with their ovipositor and feeding on the leaf juices exuding from the wound. Males lack the ability to directly damage the plants but often feed from wounds made by the females. After a pre-egg-laying period of 15 to 30 hours, the female lays an average of 17 eggs per day, or approximately 250 eggs during her lifetime. About 15 percent of all feeding punctures are actually used for egg-laying, but this varies with temperature, age of the female, and maturity of the leaf. The life expectancy of both sexes is less than 30 days; females live longer than males.

Eggs are laid just beneath the leaf surface. After 2.5 to 4.5 days, the young larva hatches from the egg and begins feeding on the palisade parenchyma (within the leaf, below the upper surface). The larva passes through three stages as it makes the characteristic serpentine mine, completing development in 5 to 7 days. When ready to pupate, the third-stage larva cuts a hole in the leaf surface, crawls out of the mine, and drops to the ground. Pupation usually takes place in cracks and crevices in the soil. Adults emerge within 10 to 12 days. At warmer greenhouse temperatures, the egg-adult cycle can be completed in less than 20 days.

Forty-seven genera in ten families have been recorded as hosts of *L. trifolii*. In California we have collected this species from the following economically important crops: chrysanthemum, aster, calendula, cineraria, gerbera, baby's breath, snapdragon, sugar bean, tomatoes, mellons, cucumbers, and celery. Chrysanthemums do not appear to be a preferred host.

Monitoring

Leafminer populations can be assessed by counting adults, larvae, or pupae. Adult flight activity is monitored in the morning by sweeping beds or by counting the number of adults trapped as they land on small yellow sticky traps. Adult emergence from the soil can be monitored with inverted funnels. Larvae are monitored by selecting leaves and examining them visually for the presence of mines with larvae. Larvae emerging from the leaves can be assessed with the aid of small trays placed on the ground within chrysanthemum beds. Larvae that emerge from the leaves and fall into these trays, pupate, and can be counted.

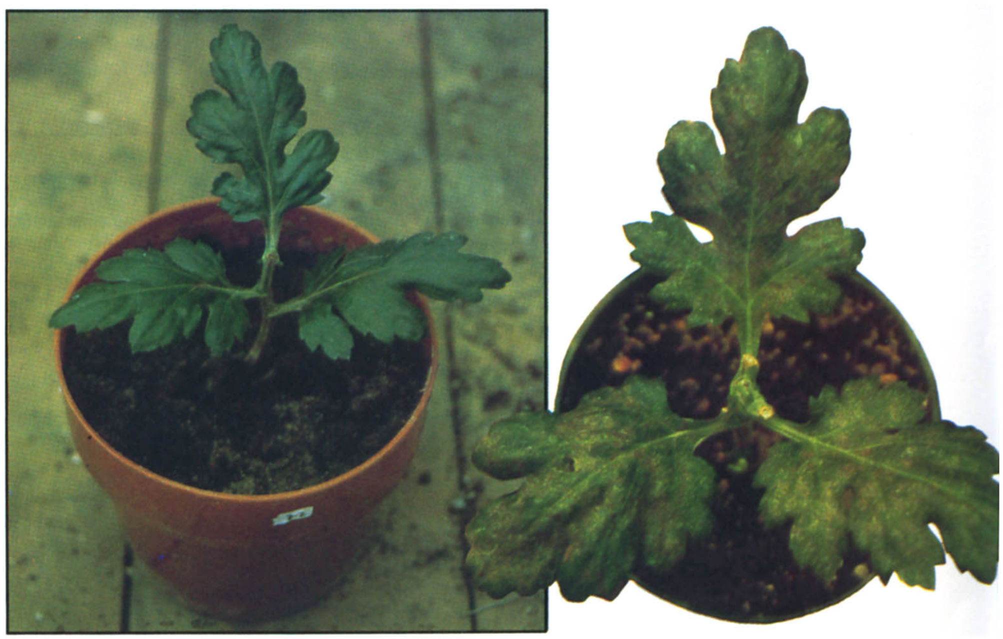
Monitoring gives only rough indications of fly populations present in the greenhouse. Good quantitative data relating any monitoring technique to actual plant damage are not yet available. However, the techniques can be useful in detecting early stages of a population buildup, particularly if situated near entry points (such as doors or holes in plastic) or near the more susceptible chrysanthemum varieties.

Chemical control tests

Numerous field trials were conducted with cooperating growers in Encinitas, El Modena, and Salinas during 1977-79. Two will be

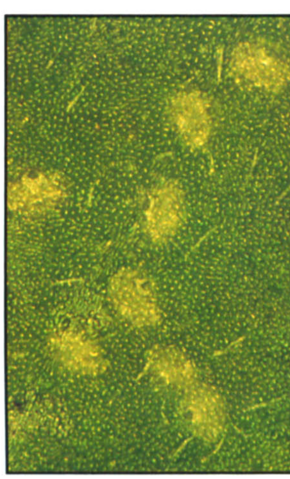
Three leafminer species attack a wide range of California vegetables and flowers (from left): *Liriomyza trifolii, L. sativae, L. huidobrensis.*

Healthy chrysanthemum plant (left) and one mined by *Liriomyza trifolii.*

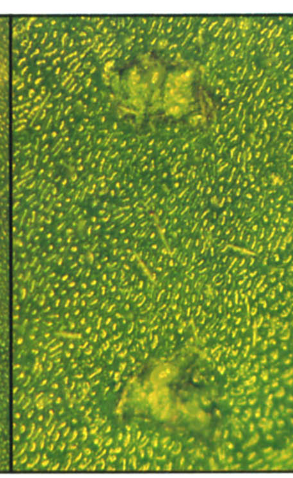


Typical serpentine leafmine of *Liriomyza trifolii* and feeding/egg-laying punctures.

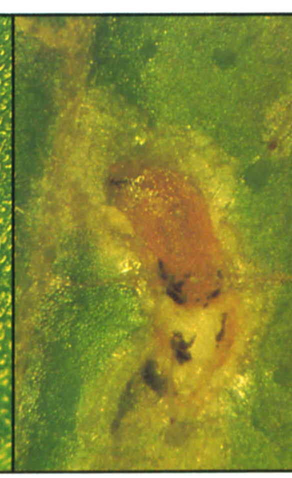
Leafminer punctures.



Leafminer egg in leaf.



Third-stage larva.



Leafminer puparium.

discussed here.

In trial A at Salinas, one application of selected rates of Penncap M 2E was applied as full-coverage sprays on September 12, 1978. A wetting agent (Triton AG98) was added to one treatment.

Counts, made 1, 2, and 3 weeks after application, were based on the number of living pupae and larvae in 20 leaves from each of four replications. Larvae and pupae were counted after the leaves had been held in plastic bags for 7 days. The most effective rate was 1 pound active ingredient per 100 gallons water, which provided good control for up to 14 days after application (table 1).

In trial B at El Modena, 12 weekly applications of Vydate 2E, SBP 1513 1E, and Penncap M 2E were made from November 4, 1978, to January 29, 1979. Originally Temik 10G, applied twice a month, was to be evaluated along with these other materials, but applications were discontinued because of very poor control.

A randomized design was used with four replications per material. Each plot covered one-fourth of a 10,000-square-foot greenhouse. Insecticides were applied by a handsprayer to the point of runoff. Twelve yellow 1-square-foot sticky traps, 3 feet above the ground, were evenly spaced throughout each treatment area. All materials except Temik 10G (later switched to Vydate 2E) provided satisfactory control (table 2).

When these tests were conducted, several materials applied weekly controlled *L. trifolii* on chrysanthemums. In 1977, many of these materials were not registered for use on chrysanthemums in California. By 1980 both permethrin (Pounce 3.2E and Pramex 2E) and Oxamyl (Vydate 2E) were granted registration in California, but during the summer of 1980, these materials failed to provide control even with applications as often as every 3 days. In our field trials, Penncap M 2E was the only material that satisfactorily reduced leafminer populations. A 24C "special local needs" registration for Penncap M 2E for use on greenhouse mums in California has been granted.

The seriousness of the leafminer problem in California, which has been intensified by the failure of most conventional insecticides, has demonstrated the need for considerable basic research. Investigations of this insect with respect to bionomics, natural enemies, sampling methodology, toxicology, and the like are under way to develop a leafminer management program.

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TABLE 1. Effectiveness of Varying Rates of Microencapsulated Methyl Parathion for Control of *Liriomyza trifolii* in Chrysanthemum Leaves, Trial A, Salinas, 1978

Insecticide	Post-treatment count of larvae and pupae after*		
	7 days	14 days	21 days
Penncap M 2E:			
1.0 lb ai/100 gal	2 a	4 a	27 c
0.50 lb ai/100 gal	9 b	20 b	32 c
0.50 lb ai/100 gal + Triton AG 98† (2oz/100 gal)	8 b	22 b	42 c
0.25 lb ai/100 gal	22 c	44 c	33 c
0.12 lb ai/100 gal	77 d	68 c	61 c
Check	98 d	92 c	56 c

*Means in the same column followed by the same letter are not significantly different (p > 0.01), Duncan's Multiple Range Test. Data were transformed (log [X + 1]) for analysis when necessary.
†Low-foam general-purpose agricultural adjuvant.

TABLE 2. Effectiveness of 12 Successive Applications of Selected Insecticides to Control *Liriomyza trifolii* on Chrysanthemums, Trial B, El Modena, 1978-79

Insecticide	Mean number of adults per trap on following dates:															Leafminer-free cuttings*
	10/31	11/7	11/14	11/21	11/28	12/5	12/12	12/19	12/27	1/3	1/9	1/16	1/23	1/30	2/6	%
Temik 10G† (4 lb ai/acre)	418	564	320	245	372	158	285	184	72	22	138	151	153	287	321	20.0
Vydate 2E (8 oz ai/100 gal)	1,092	1,165	563	328	312	449	326	184	80	63	90	227	143	83	61	97.0
SBP 1513 1E (1.0 oz ai/100 gal)	—	836	569	393	188	97	81	67	13	17	4	11	5	13	4	97.0
Penncap M 2E (8 oz ai/100 gal)	—	368	168	112	58	24	10	12	1	7	5	2	1	1	1	97.0

*Based on grower's assessment.
†Discontinued after 11/26; Vydate 2E was used thereafter.

Liriomyza trifolii could become a problem on celery

John T. Trumble

An outbreak of leafmining flies in the genus *Liriomyza* occurred on celery in Ventura County, California, during the summer and fall of 1980. Leafminers reared from celery and squash grown in the area were identified as *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae), providing the first evidence of economically important infestations of this species on celery in California.

Celery leaf mined by *Liriomyza trifolii.*